Design Memorandum No. 03-2005

TO:	Engineering Offices and Divisions Districts Consulting Engineers
FROM:	Mark S. Gaydos, P.E. – Design Engineer /s/
DATE:	March 2, 2005
SUBJECT:	PREVENTIVE MAINTENANCE - REVISED COST EFFECTIVENESS GUIDELINES

Design Manual Reference:
Section I-06.05 and
Appendix I-06 C
_____Revision
__✓__ Supplemental

Section II-05.04.03 and
Appendix II-05 G
__✓__ Revision
_____ Supplemental

Introduction
This guidance is intended to supplement Design Memorandum No. 01-03, *Preventive Maintenance Guidelines*, December 3, 2001, and to replace Design Memorandum No. 02-01, *Preventative Maintenance Cost Effectiveness Guidelines,* February 19, 2002, by providing a revised basis of cost effectiveness for various preventive maintenance (PM) strategies using updated construction costs. The tables have been revised since Design Memorandum No. 02-01, *Preventative Maintenance Cost Effectiveness Guidelines.*

Implementation
This guidance is to be implemented immediately. The project concept reports for preventive maintenance strategies should include a section addressing cost effectiveness similar to the following:

Cost Effectiveness:

Estimated Service Life of Proposed Improvement: ___________________ yrs
Estimated Cost/Mile: $ _____________________

☐ The estimated design life and estimated cost per mile are within the range determined by the NDDOT to be cost effective for the proposed improvements.

☐ A Cost Effectiveness Analysis attached.

For work activities not identified in the Preventive Maintenance Cost Effectiveness Guidelines, the cost effectiveness shall be determined by comparing the Life Cycle Costs (Net Present Worth) for the proposed work versus reconstruction or other appropriate work.

Guidance
Preventive maintenance is a planned strategy of cost effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system without substantially increasing structural capacity. Preventive maintenance should be performed on **structurally sound highways**. The intent is to get 5-10 years extended service life with the preventive maintenance strategy.

Preventive maintenance project approvals are advanced with the understanding that geometric and safety enhancements generally will not be performed on the current project, but will be an integral part of a future 3R or reconstruction project. Preventive maintenance or minor work items shall not degrade existing safety or geometric aspects of a facility.
A preventive maintenance activity is eligible for Federal aid if the State demonstrates that the activity is a cost effective means of extending the service life of a Federal aid highway per the NHS Designation Act of 1995.

The cost effectiveness provided in this document is based on comparing preventive maintenance costs to savings shown through delay of major rehabilitation/overlay or reconstruction costs using the life cycle cost analysis. The life cycle cost analysis does not consider pavement condition. Therefore, this methodology assumes that all the pavement options being compared provide the same level of service and that the preferred option is the one that minimizes life cycle costs.

Another cost effectiveness methodology considers benefits received by users and the cost to provide those benefits or benefit-cost analysis. Benefits to users of a well maintained pavement include reduced crashes, reduced travel times, reduced vehicle operating and maintenance costs, reduced disruptions to adjacent businesses, increased motorist comfort, and reduced or deferred capital expenditures through the preservation of a capital asset. As the benefits to the user are difficult to quantify in monetary terms, this method was not considered.

Project development for preventive maintenance activities should include a review of actual highway conditions and pavement management data provided by the Planning and Programming Division. Guidance for the selection of appropriate preventive maintenance treatments is provided with the following publication:

> "Selecting a Preventive Maintenance Treatment for Flexible Pavements", Publication No. FHWA- IF-00-027, August 2000.

The following identifies several preventive maintenance strategies and corresponding cost effectiveness analysis (costs per mile for the various strategies are the result of averaging actual representative project costs on a per mile basis and includes all project and engineering costs):

Flexible Pavements: Asphalt/Hot Bituminous Pavement (HBP) or Composite: Asphalt Over Continuously Reinforced Concrete (AOCRC) or Asphalt Over Plain Jointed Concrete (AOPJC)

> <u>Seal Coats</u> – Seal coats that are added within 3-4 years of the hot bituminous pavement are approved as part of phased construction and do not require a cost effective analysis. The seal coat is placed to prolong the life of the pavement, to correct surface raveling and oxidation, to seal minor cracks preventing the intrusion of water, and to improve friction values.

Tables 1 and 2 illustrate the cost effectiveness for seal coats on Non-Interstate and Interstate highways. The seal coats are projected to extend the service life by 2-3 years for each seal coat application. The estimated cost per mile should be about $16,000/mi for non-interstate highways and $21,000/mi for interstate highways (two lanes).

Micro Surfacing – This procedure is used to improve ride qualities, fill ruts (reestablish cross section), seal (severe raveling and stripping), and to improve friction values. It could also be used in place of a seal coat if conditions warranted, although it is more costly.

Table 3 illustrates the cost effectiveness for micro surfacing. The micro surfacing is projected to extend the service life by 7-10 years. The estimated cost per mile should be about $56,000/mi for two-lane highways.

Thin Lift Overlay – This procedure is used to retard deterioration, to improve the ride quality, correct surface variations, and to improve surface drainage and frictional characteristics of the highway.

To qualify as preventive maintenance, the thin lift overlay is limited to one overlay per pavement life, not to exceed $1^{1}/_{2}$", plus 50 ton per lane mile for repairs, leveling, patching, etc, as provided by department preventive maintenance guidelines. The thickness and tonnage limitation as well as the limitation of one application of the strategy per life of the roadway section have been agreed upon as the maximum to be considered preventive maintenance to distinguish this work from structural overlays which are 3R and therefore subject to consideration of safety improvements.

Table 4 illustrates the cost effectiveness for thin lift overlays. The thin lift overlay is projected to extend the service life by 7-10 years. The estimated cost per mile should be about $60,000/mi for two-lane highways.

Milling – This procedure is used to restore the pavement cross section which has severe rutting and/or to remove unsatisfactory material. The surface texture after the milling should be fine enough that it can be used as the riding surface or suitable for a seal coat.
This procedure should only be used if it is determined that there is sufficient pavement section left to carry the traffic load.

The estimated cost per mile should be about $18,000/mi for two-lane highways. A separate cost effectiveness was not completed for this activity, as milling would generally be performed in conjunction with other activities such as seal coats or overlays.

Rigid Pavements: Portland Cement Concrete (PCC) - Jointed or Continuously Reinforced

Minor Concrete Pavement Repair (CPR) – This procedure is used to repair spalling, blow-ups, broken panels, punchouts, finger joint repair or replacement, joint resealing, crack sealing, underdrain repair or cleaning, and pavement grinding. This is done to reduce the effects of these deficiencies, improve the ride, and extend the roadways service life before major rehabilitation or reconstruction is required.

Tables 5 and 6 illustrate the cost effectiveness for minor CPR. The minor CPR is primarily provided to improve ride quality which delays major rehabilitation or reconstruction; thereby extending the service life by 5-10 years. The minor CPR may also be completed in advance of a HBP overlay project. The estimated cost per mile should be about $20,000/mile. Two minor CPR applications may be applied in the life of a roadway section before considering the work a 3R strategy subject to consideration of safety improvements.

Grinding – Grinding is considered an acceptable minor concrete pavement repair strategy. This procedure is used on concrete pavement to correct faulting at the transverse joints to improve the quality of the ride and reduce the impact loading. It also improves the friction characteristics of the roadway.

The cost effectiveness for grinding is illustrated on Table 7.

Note: Projects for which the estimated costs exceed $75,000 per mile will be categorized as major CPR projects and will need to be processed as 3R Type projects to address safety enhancements and geometric aspects of the highway.

Cost Effectiveness Analysis (Life Cycle Cost)

The life cycle costs refer to all the costs that are anticipated for the life of the facility or pavements. This includes identifying and evaluating the economic consequences of various alternatives either over time or over the life cycle of the pavement.

In the following tables, various PM methods for both HBP and PCC pavements are compared to surfacing, reconstruction, or other PM alternatives. The life cycle costs are based on the construction costs and the salvage value. The salvage value is the prorated cost of the remaining design life of the in-place pavement based on delay for major rehabilitation/overlay or reconstruction. The costs are converted into today's dollar value through a method called the Present Worth (PW) Method. This method involves the conversion of all present and future expenses to a base of today's costs. The PW value is given by the equation: $PW = F(1 + i)^{-n}$. Where: F represents the future sum of money at the end of "n" years from present; "n" represents the number of years, and "i" is the discount rate. A 4% discount rate was used for the computation of the present worth values. The construction costs are developed on the basis of project cost history provided by the Planning and Programming Division (Attachment 1). The tables show whether performing PM on the existing pavement is cost effective for extending the pavement service life and delaying major rehabilitation/overlay or reconstruction, based on the design life of the PM method chosen.

To use the tables, it is necessary to determine what preventive maintenance strategy would best extend the service life of the existing section. Then a judgement needs to be made as to the estimated service life that the PM strategy would have when applied to the given roadway section. After selecting the appropriate chart and finding the estimated service life, cost effectiveness is determined by where the estimated service life of the PM strategy (left column) falls in relation to the present worth of the alternative capital investment (right column). The estimated cost per mile for the PM strategy is to be less than the present worth of the alternative capital investment strategy (10% variance may be allowed due to the variability of estimating).

Example: The District has concluded that a segment of ND 3 is structurally sound; has a fair ride, minor rutting, and relatively good joints (no spalling and tight). It is intended to extend the service life by placing a thin lift overlay on the segment of highway, rather than a structural overlay. The District believes the thin lift overlay will last 7 years or more. Referring to Table 4, the Life Cycle Cost for a PM thin lift overlay, with an estimated service life of 7 years, is

$150,000 per mile, which is less than or equal to the estimated cost of $150,000 per mile for a 3R Structural Overlay strategy. Additionally, the actual estimated cost of the PM thin lift overlay is $52,000 per mile, which is less than the estimated cost of $60,000 per mile for the PM Thin Lift Overlay strategy. Therefore, the PM thin lift overlay is shown to be cost effective. For a predicted service life of 7 years or greater, the table shows the cost to be cost effective for this strategy.

For PM activities that are not provided in the tables, a separate cost effectiveness analysis should be included in the discussion or attached to the project concept report. If the cost is not shown to be cost effective on the table than a project specific cost effective analysis should also be conducted. For these PM activities, contact James Rath in the Design Division for guidance on the cost effectiveness analysis.

It should be noted that Tables 8, 9, and 10 for Major CPR, HBP Resurfacing, and Major CPR & HBP Resurfacing are provided for comparative purposes only. These strategies are **not** considered to be preventive maintenance strategies.

References

1. Geoffroy, Donald N., *NCHRP Synthesis of Highway Practice 223: Cost-Effective Preventive Pavement Maintenance*, Transportation Research Board, National Research Council, Washington, DC (1996)

2. *Selecting a Preventive Maintenance Treatment for Flexible Pavements*, Publication No. FHWA-IF-00-027, Federal Highway Administration, Washington, DC (August 2000)

Questions

Any question regarding the content or implementation of this memorandum should be referred to Ron Henke, Design Division, 701-328-4445.

Approved

/s/ — 3/30/05

Francis G. Ziegler, P.E. – Director of Project Development — Date

LEGEND:	
(shaded)	--- Cost Effective
(unshaded)	--- Not Cost Effective

TABLE 1

NON-INTERSTATE THREE SEAL COAT TREATMENTS		
		Estimated Design Life of HBP Surfacing (Est. Cost = $200,000)
		20
Extended Se/vice Life of 3R Struct. Overlay (Est. Cost = $150,000 & 3 @ $16,000)	1	$180,100
	2	$176,700
	3	$173,200
	4	$169,800
	5	$166,400
	6	$163,000
	7	$159,500
	8	$156,100
	9	$152,700
	10	$149,300

TABLE 2

INTERSTATE THREE SEAL COAT TREATMENTS		
		Estimated Design Life of HBP Resurfacing (Est. Cost = $330,000)
		20
Extended Service Life of HBP Resurfacing (Est. Cost = $330,000 & 3 @ $21,000)	1	$366,400
	2	$358,900
	3	$351,400
	4	$343,800
	5	$336,300
	6	$328,800
	7	$321,300
	8	$313,700
	9	$306,200
	10	$298,700

TABLE 3

PM MICRO SURFACING		
		Estimated Design Life of 3R Struct. Mill & Overlay (Est. Cost = $167,600)
		20
Estimated Service Life of PM Micro Surfacing (Est. Cost = $56,000)	1	$213,300
	2	$203,300
	3	$193,500
	4	$184,000
	5	$174,600
	6	$165,500
	7	$156,600
	8	$147,900
	9	$139,300
	10	$131,000

TABLE 4

PM THIN LIFT OVERLAY		
		Estimated Design Life of 3R Structural Overlay (Est. Cost = $150,000)
		20
Estimated Service Life of PM Thin Lift Overlay (Est. Cost = $60,000)	1	$200,800
	2	$191,800
	3	$183,100
	4	$174,500
	5	$166,200
	6	$158,000
	7	$150,000
	8	$142,200
	9	$134,600
	10	$127,100

LEGEND:	
(shaded)	--- Cost Effective
(unshaded)	--- Not Cost Effective

TABLE 5

MINOR CPR		
		Estimated Design Life of Major CPR (Est. Cost = $200,000)
		15
Estimated Service Life of Minor CPR (Est. Cost = $20,000)	1	$204,900
	2	$190,100
	3	$175,600
	4	$161,300
	5	$147,400
	6	$133,600
	7	$120,200
	8	$106,900

TABLE 6

MINOR CPR (TWICE)		
		Estimated Design Life of Major CPR (Est. Cost = $200,000)
		15
Estimated Service Life of First Minor CPR (Est. Cost = $20,000)	1	$166,600
	2	$152,100
	3	$137,900
	4	$124,000
	5	$110,300
	6	$96,900
	7	$83,700
	8	$70,700

LEGEND:	
(shaded)	--- Cost Effective
(unshaded)	--- Not Cost Effective

TABLE 7

MINOR CPR (GRINDING)		
		Estimated Design Life of Major CPR (Est. Cost = $200,000)
		15
Estimated Design Life of Grinding (Est. Cost = $40,000)	1	$224,900
	2	$210,100
	3	$195,600
	4	$181,300
	5	$167,400
	6	$153,600
	7	$140,200
	8	$126,900

TABLE 8

MAJOR CPR		
		Estimated Design Life of PCC Reconstruction (Est. Cost = $1,300,000)
		30
Estimated Service Life of Major CPR (Est. Cost = $200,000)	1	$1,436,600
	2	$1,375,200
	3	$1,315,600
	4	$1,257,800
	5	$1,201,700
	6	$1,147,200
	7	$1,094,400
	8	$1,043,000
	9	$993,100
	10	$944,600

TABLE 9

HBP RESURFACING		
		Estimated Design Life of PCC Reconstruction (Est. Cost = $1,300,000)
		30
Estimated Service Life of HBP Resurfacing (Est. Cost = $330,000)	1	$1,566,600
	2	$1,505,200
	3	$1,445,600
	4	$1,387,800
	5	$1,331,700
	6	$1,277,200
	7	$1,224,400
	8	$1,173,000
	9	$1,123,100
	10	$1,074,600

TABLE 10

CPR & HBP RESURFACING		
		Estimated Design Life of PCC Reconstruction (Est. Cost = $1,300,000)
		30
Estimated Service Life of CPR (Est. Cost = $73,300 & $330,000)	1	$1,088,100
	2	$1,030,100
	3	$973,700
	4	$919,100
	5	$866,000
	6	$814,400
	7	$764,300
	8	$715,700

Note: Tables 8, 9, and 10 for Major CPR, HBP Resurfacing, and Major CPR & HBP Resurfacing are provided for comparative purposes only. These strategies are not considered to be preventive maintenance strategies.

Appendix 1

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PROJECT COST HISTORY

INTERSTATE

Rural

PCC Paving	PCC paving at $1,300,000 per mile
CPR	CPR at $20,000 per mile CPR-Grind-Dowel Bar Retrofit at $200,000 per mile
Resurfacing (HBP)	Surface at $330,000 per mile
Federal Aid Seal Coats	$21,000 per mile

NON-INTERSTATE

Rural

Reconstruction	Grade, including 12" base at $475,000 per mile
Surfacing (HBP)	Surface at $200,000 per mile, new surfacing Surface at $150,000 per mile, overlays, etc.
Blend (Includes HBP)	$250,000 per mile (NON-NHS) $275,000 per mile (NHS) (4 lane divided) $320,000 per mile (NHS) (2 Lane)
Widen with blended base & HBP	$500,000 per mile
Widen prior to blended base	$300,000 per mile
Federal Aid Seal Coats	$16,000 per mile
Thin Lift Overlays (1 ½” or less)	$60,000 per mile
Microsurfacing	$56,000 per mile

Urban

Reconstruction	51' curb and gutter $3,540,000 per mile 63’ curb and gutter $3,900,000 per mile
Surfacing	Mill and overlay at $780,000 per mile

Revised February 15, 2005